

LA-UR-18-24248

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Title: Scientific Excellence for Mission Impact

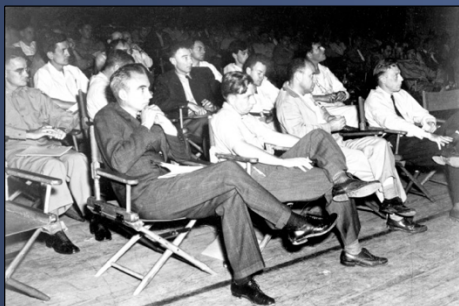
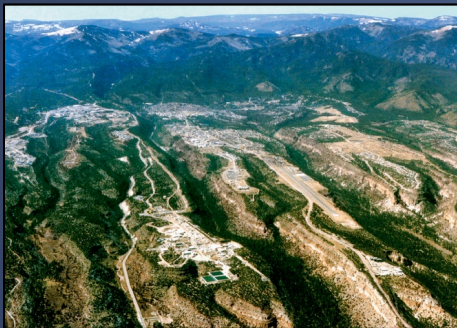
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SCIENTIFIC EXCELLENCE FOR MISSION IMPACT

The Importance of Collaborations

Alan Bishop
Chief Scientist
Los Alamos National Laboratory

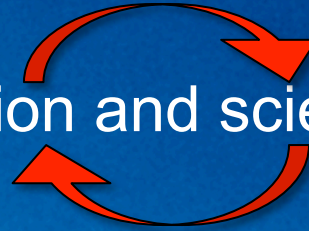
May 18, 2018



The background of the slide is a composite image. On the left, a rocket is shown launching from a launchpad, with a DNA double helix structure overlaid on it. A rainbow is visible in the sky behind the rocket. On the right, there is a landscape with a large, flat-topped mountain or mesa under a clear blue sky.

LOS ALAMOS:

Where great mission and scientific frontiers meet



- ***What We Do...***

Interdisciplinary science of systems at scale: Integrating, measuring, modeling, simulating & engineering assets
– From understanding to prediction, design, and mitigation

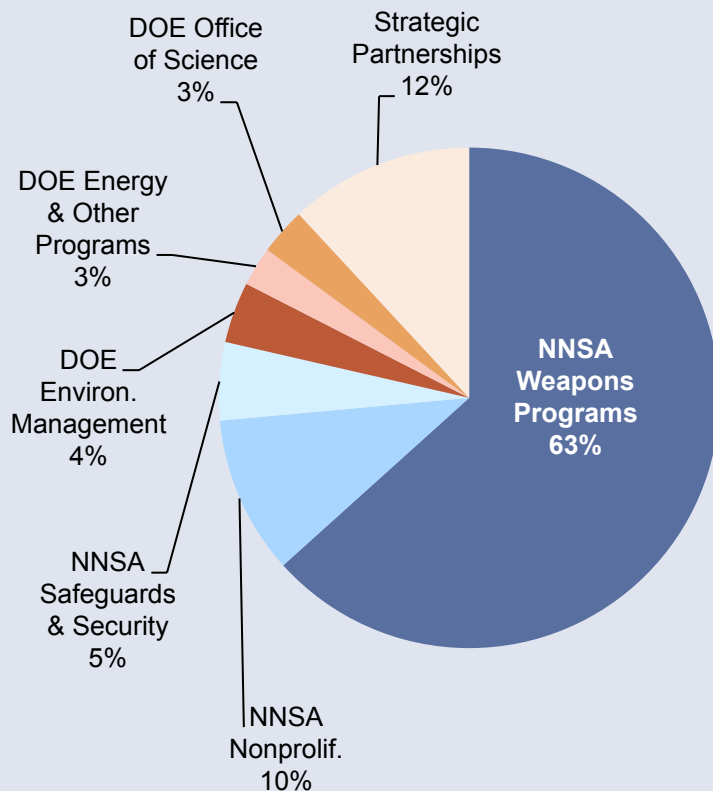
- ***...and Why We Do It***

To accelerate discovery-to-innovation for technology delivery and national security impact

~ 40 square miles; ~ 11,700 employees; > \$2.5B annual budget

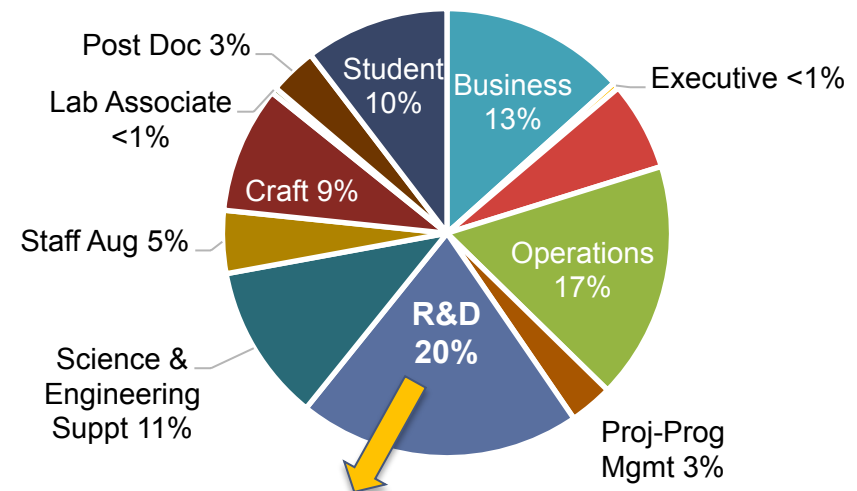
As a National Security **Laboratory**, applying multidisciplinary capability is inherent in our broad funding and workforce base

FY18 Estimated Budget Authority: > \$2.5B

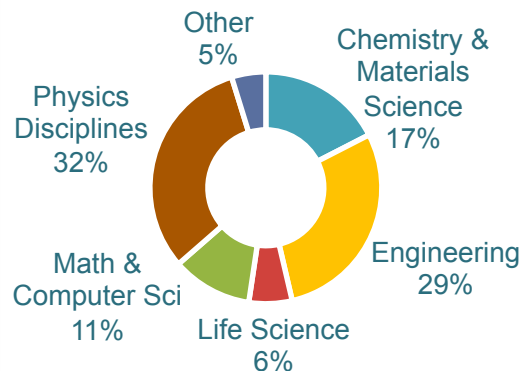


Approx. 11,700 National Security specialists collaborate in a wide variety of technical disciplines

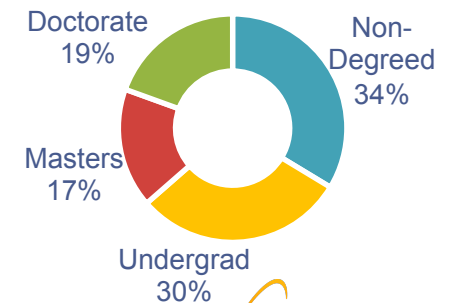
Employee Categories



R&D Employee Disciplines



Degreed Workforce

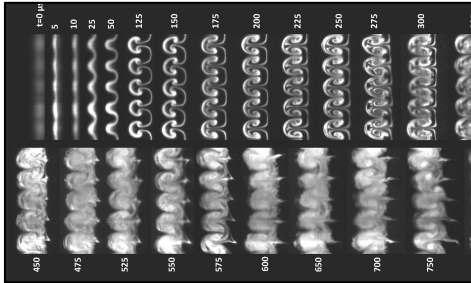


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As a **Laboratory**, Los Alamos stewards broad and deep **STE capabilities** for multi-program leverage and benefit

Stockpile Stewardship



Fluids & turbulence research

Understanding fluid dynamics in extreme environments



Supercomputer modeling & simulation

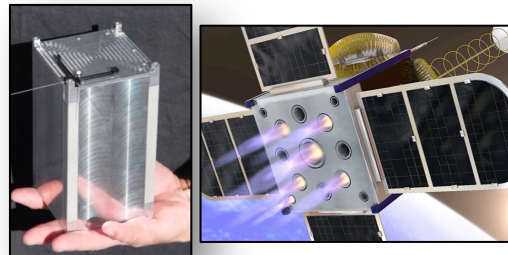
Kinetic plasma modeling

Global Security



Muon tomography

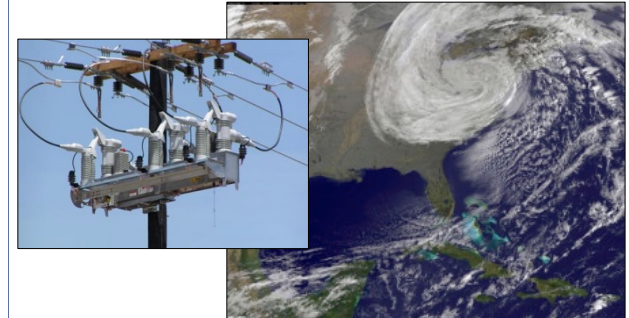
Scanner in Bahamas;
Imaging Fukushima Daiichi reactors; Mapping cracks in Brunelleschi's dome, Florence



Security from space

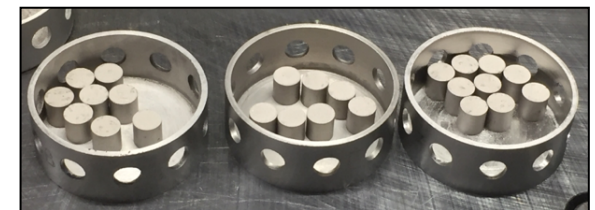
Developing and delivering space payloads for global security

Energy Security



Energy Infrastructure

Applied network science to improve response, readiness, resilience



Accident tolerant nuclear fuel development

Fabrication of test pellets

R&D highlights: www.lanl.gov/science-innovation/science-highlights

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Mission Impact: Our history of integrating science, engineering & mission enables agile responses to national security challenges

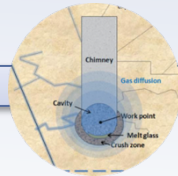
PAST

FUTURE

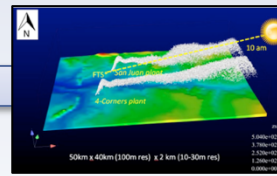
SUBSURFACE



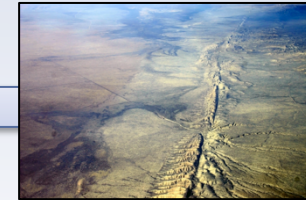
Containment
(Large events)



Nonproliferation and
verification



Environment:
Atmospheric & subsurface

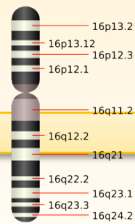


Small event detection,
Earthquake precursors,
Weapons performance

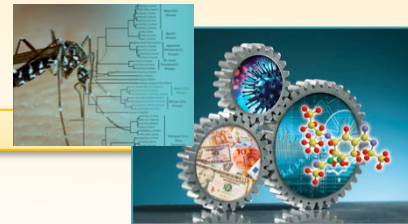
BIOSECURITY



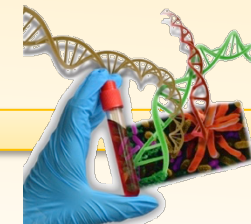
Radiation
health effects



Human Genome
Project

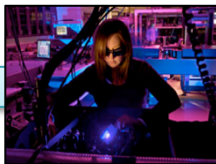


Biosurveillance,
Emergent disease tracking

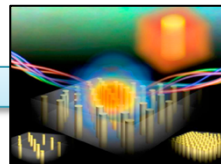


Bioinformatics, Cancer research,
Data science at scale

NANOSCIENCE



Foundational nanoscale
materials research



Metamaterials



Nanocrystal quantum dots,
Energy applications



Engineered materials/devices
Controlled functionality

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National Security & Prosperity in the “Century of Complexity”

Managing the Scientific Enterprise for this century’s societal imperatives

LOS ALAMOS NATIONAL LABORATORY

Mission Complexity



Nuclear
Deterrence

Earth/Climate
Systems

Infrastructure
Resilience



Contested/
Congested
Space

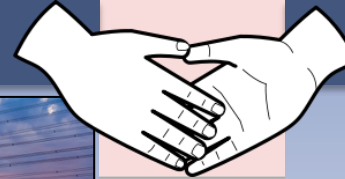
Health/
Biosecurity

Environment

Etc.

Data → Knowledge → **Security,
Resilience
Competitiveness**

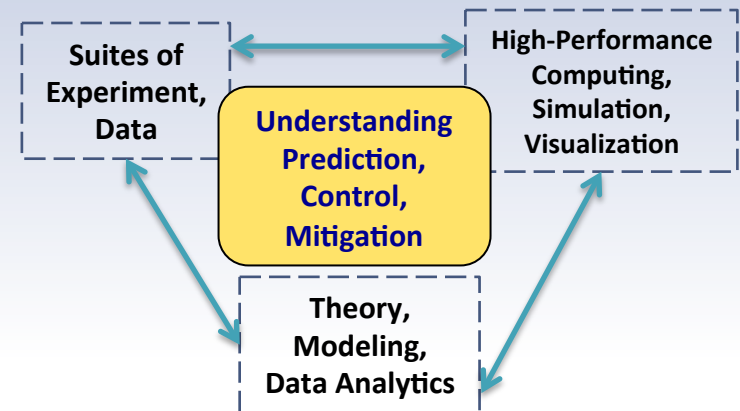
**Quantitative tools for
decision-makers/risk assessment**



STE Complexity

Science of prediction & Uncertainty quantification

Methodologies for
**Complex Natural &
Engineered Systems**



**This century’s scientific tools
enable the SCIENTIFIC METHOD
at scale for realistic systems**

Los Alamos maintains unique science and engineering facilities



Los Alamos Neutron Science Center



National High Magnetic Field Laboratory



Center for Integrated Nanotechnologies



Metropolis Center for Modeling & Simulation



Dual Axis Radiographic Hydrotest Facility



Chemistry and Metallurgy Research Facility

- » 40 square miles
- » 47 technical areas
- » 2,000 structures
- » 1,280 buildings

And many more...

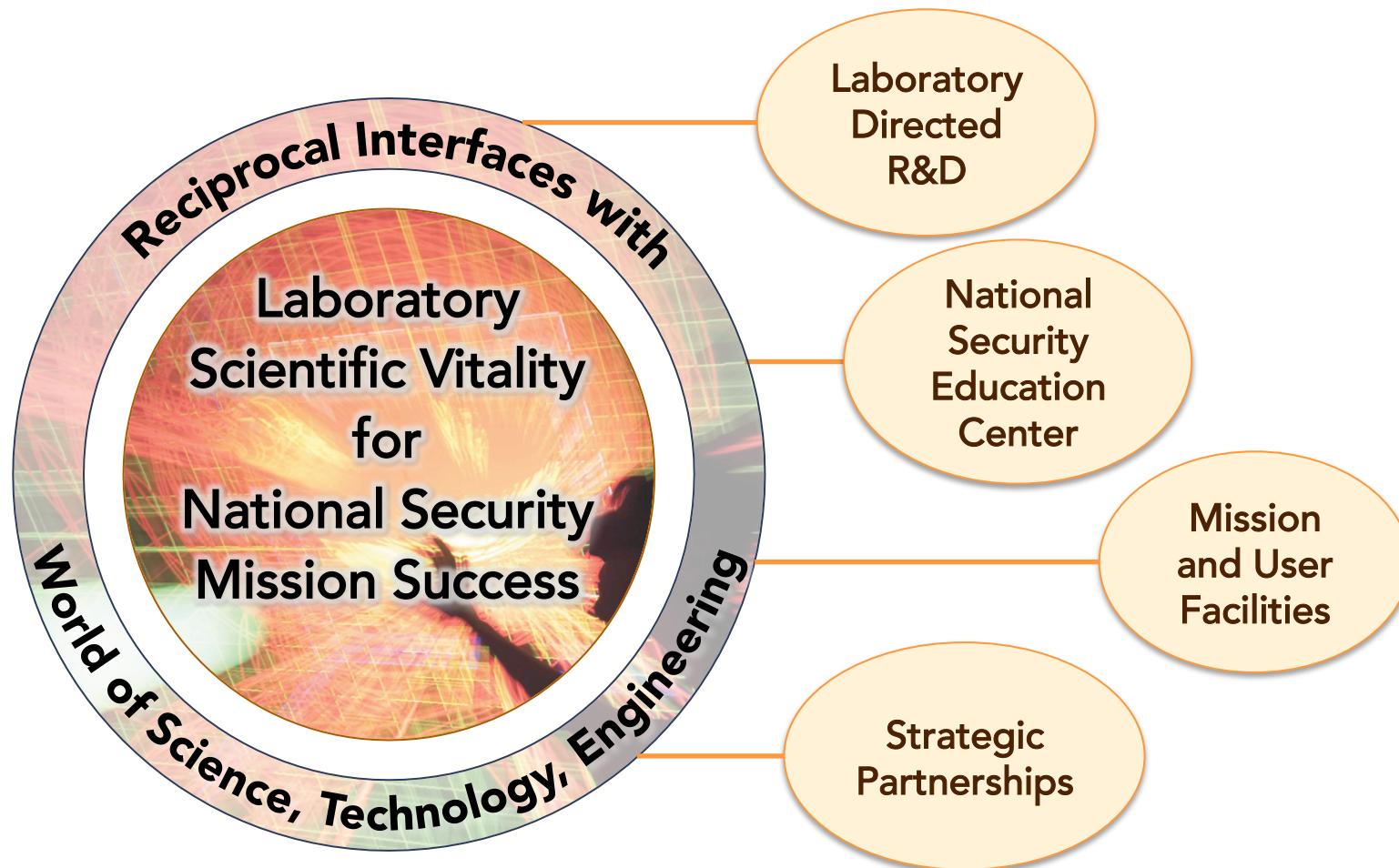


High Explosive Laboratories



Plutonium Processing Facility

Scientific (STE) vitality for mission impact requires a robust peer review and engagement ecosystem



Stewarding Reciprocal Pipelines of Talent, Ideas, Innovation

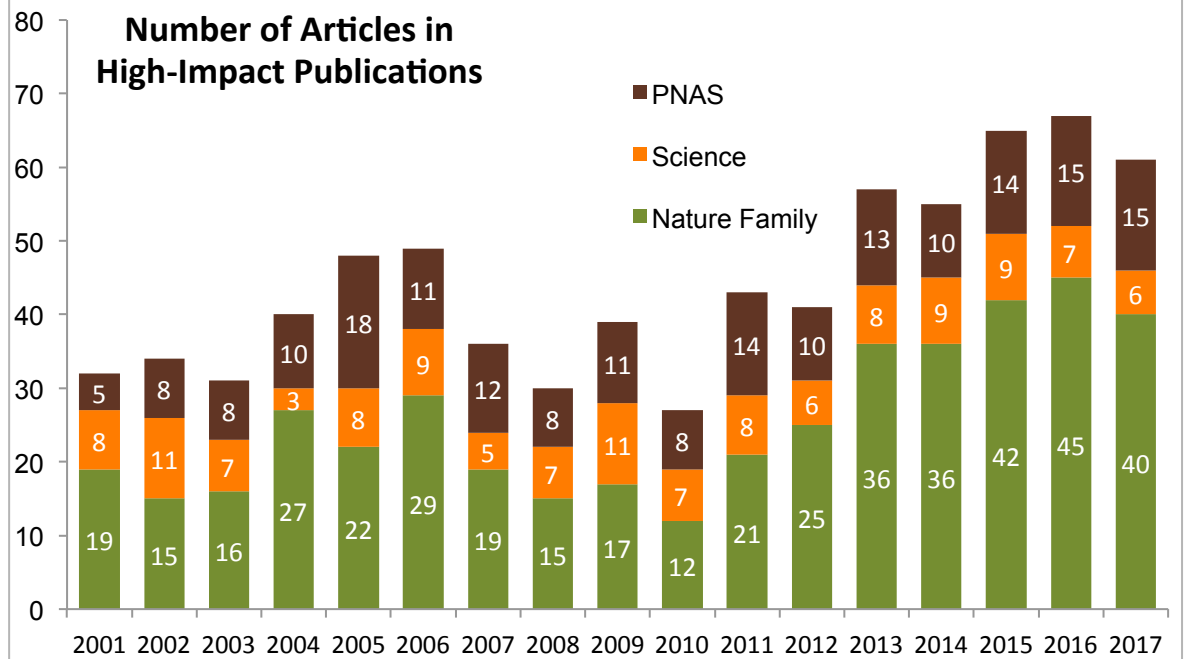
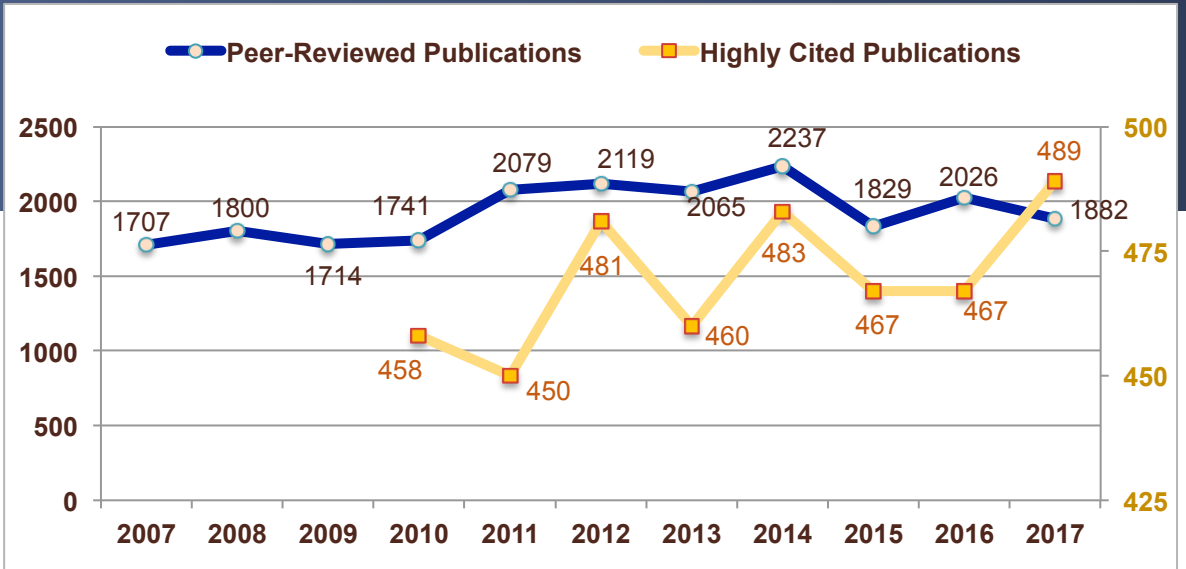
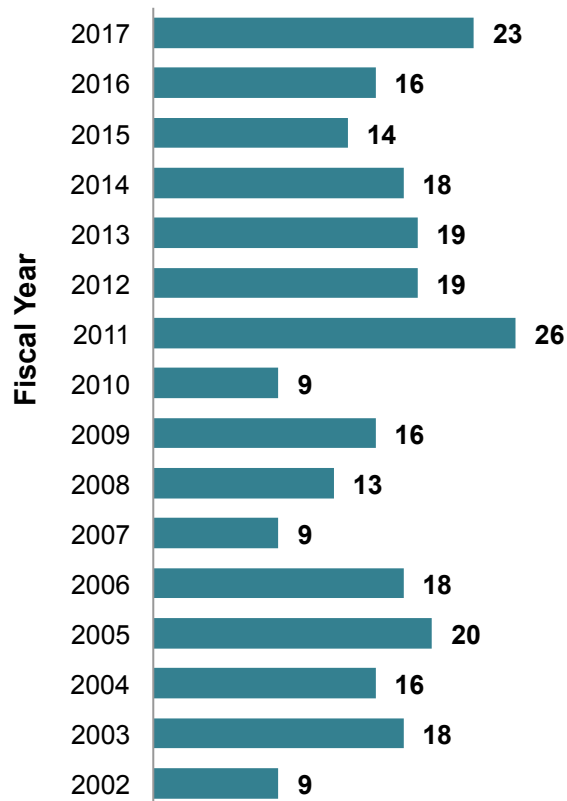
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Awards and Peer-Reviewed Publications

Number of Awards/Fellows

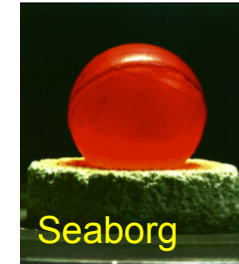
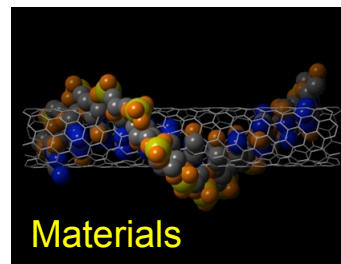
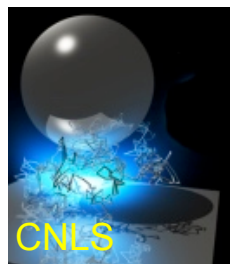
NAE, NAS, E.O. Lawrence, AAAS, APS, ACS, PECASE, R&D 100, AGU, ASA, IEEE



Los Alamos Strategic Education Centers:

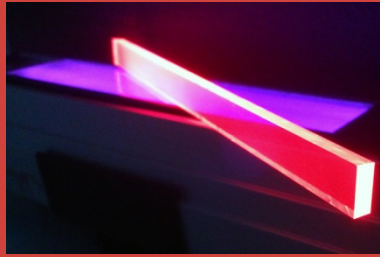
Gateways for collaboration, education, and recruitment

- **Center for Nonlinear Studies**
Interdisciplinary science of complex systems
- **Center for Space and Earth Science**
Astrophysical, space, earth & climate sciences and their signatures
- **Engineering Institute**
Structural health monitoring, cyber-physical systems
- **Institute for Materials Science**
Interdisciplinary materials and manufacturing science
- **Information Science & Technology Institute**
Education & research in IS&T
- **Seaborg Institute**
Actinide and rare earth science
- Gateways to the **New Mexico Consortium**



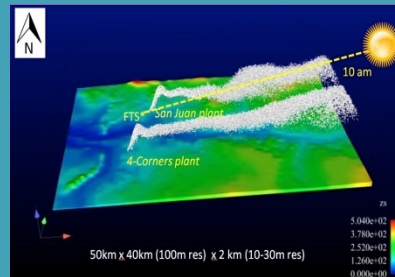
Postdocs (~380), students (~1,800), and workshops & collaborations are essential to the STE vitality of Los Alamos

Our **Science Pillars** define strategic capability investment areas at Los Alamos for present and future missions



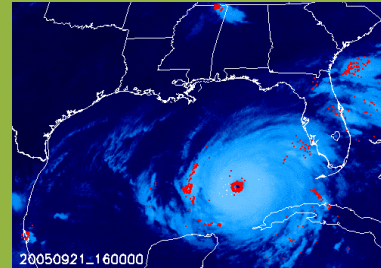
MATERIALS FOR THE FUTURE

Defects and Interfaces
Extreme Environments
Emergent Phenomena



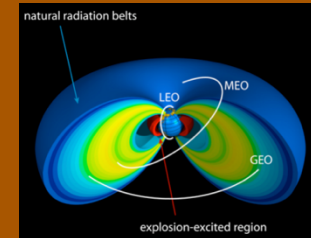
SCIENCE OF SIGNATURES

Discover Signatures
Revolutionize Measurements
Forward Deployment



INTEGRATING INFORMATION, SCIENCE, AND TECHNOLOGY FOR PREDICTION

Complex Networks
Computational Co-Design
Data Science at Scale



NUCLEAR AND PARTICLE FUTURES

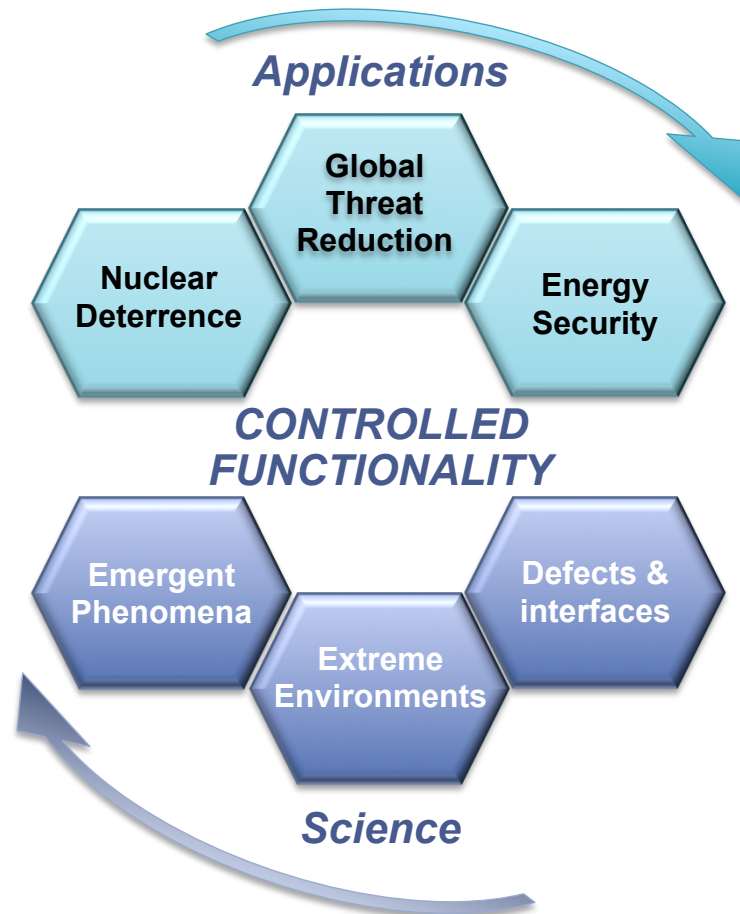
High Energy Density Physics & Fluid Dynamics
Nuclear & Particle Physics, Astrophysics & Cosmology
Applied Nuclear Science & Engineering
Accelerator Science & Technology

Science Pillars support capabilities across the Laboratory and missions

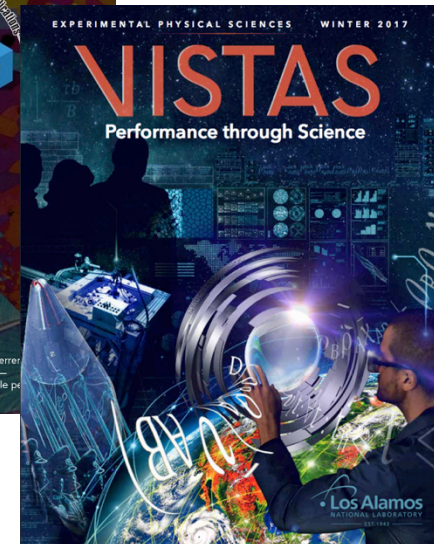
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The **Materials Pillar** advances our vision to predict and control materials and performance, enabling LANL's missions

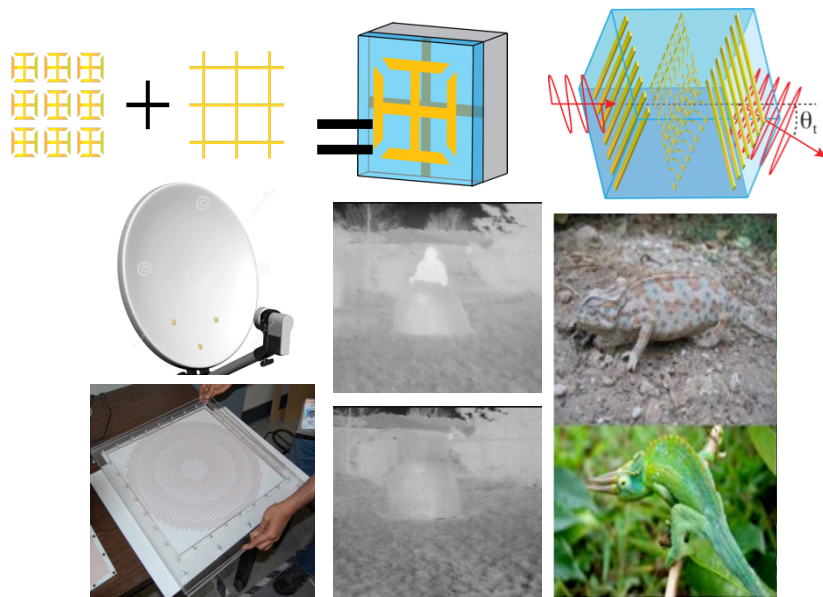


Materials Strategy
“Performance Prediction and
Controlled Functionality”



Science discovery teams with creative Engineering to support mission needs

Metamaterials for lenses and antennae

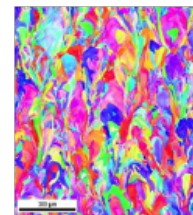


Transferring capabilities from DOE-BES to national security (enhanced communication, thermal signatures, and reflectance)

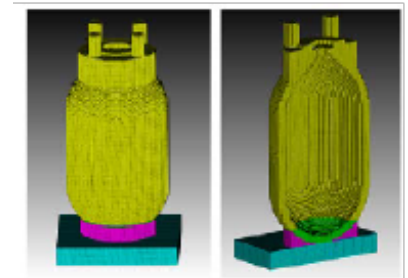
Additive manufacturing for product-based certification



Metal AM



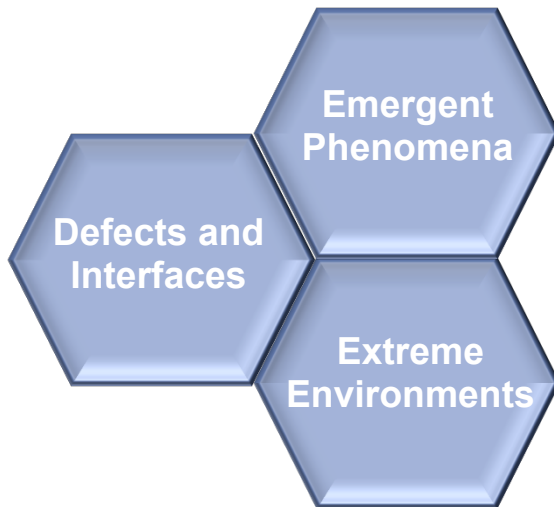
Stress characterization



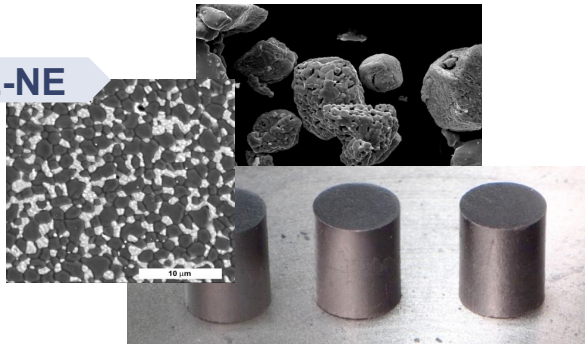
Simulation

From fundamental science to parts manufacturing, through integration of modeling (LLNL), characterization (LANL), and manufacturing (KCNCS)

Materials for the Future: Working with many DOE Programs on solutions through controlled functionality and performance



DOE-NE



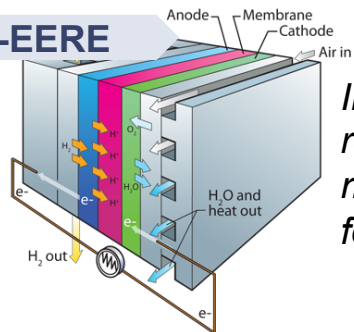
Synthesis, fabrication and testing of next generation accident-tolerant nuclear fuels

DOE-SC



Energy Frontier Research Center:
Center for Advanced Solar Photophysics

DOE-EERE



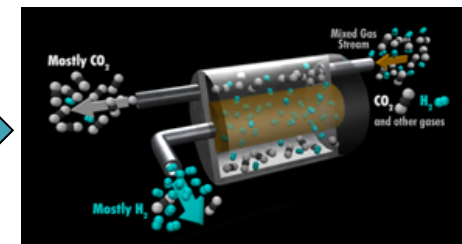
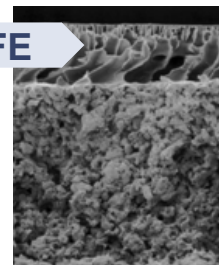
Improved routes to membranes for fuel cells

DOE-SC



Center for Integrated Nanotechnologies

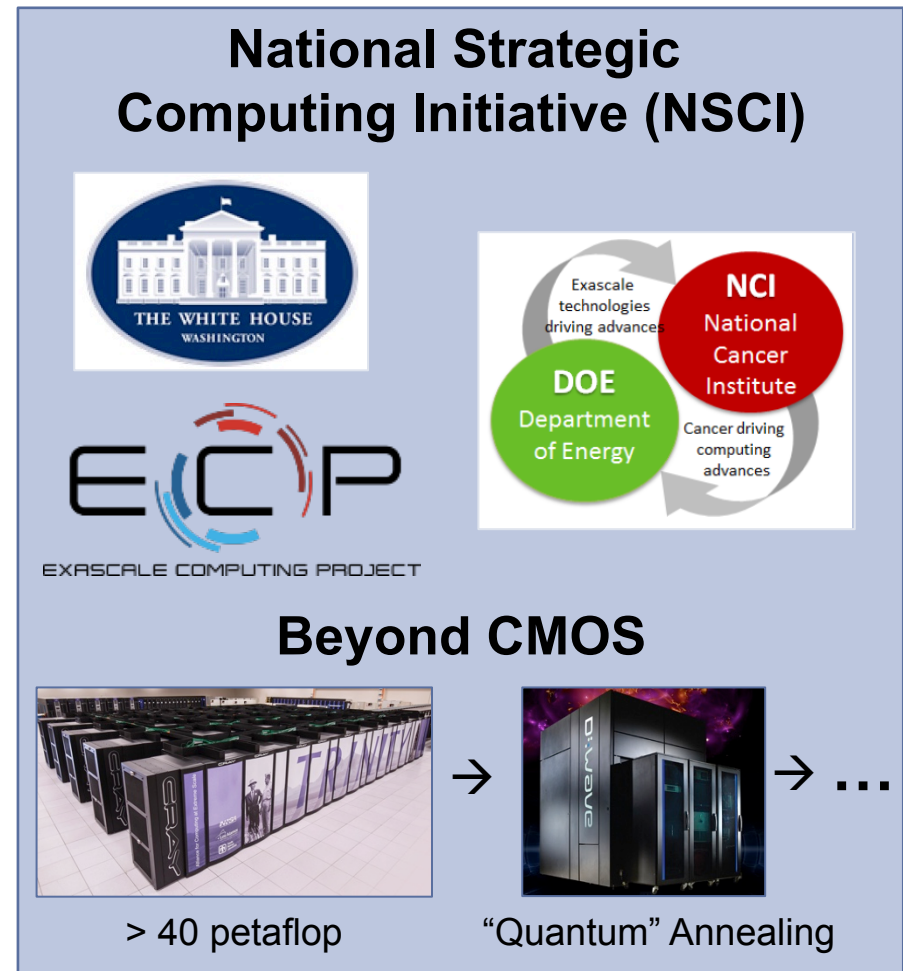
DOE-FE



New materials for carbon capture: Membrane and module design, evaluation, and scale-up

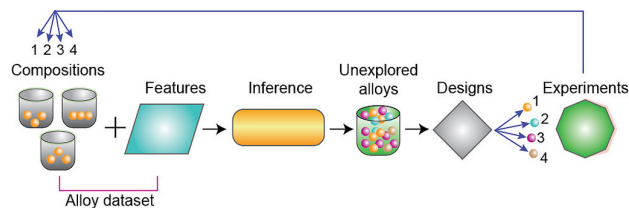
Los Alamos is committed to the exascale (and beyond) journey through co-design (Algorithms, Architectures, Applications)

- **DOE Exascale Computing Project (ECP)**
 - LANL providing leadership roles in six-lab strategy
- **“NSCI” beyond ECP and beyond CMOS**
 - National Cancer Institute partnership (LANL, LLNL, ANL, ORNL)
 - “Ising” (D-Wave) installed at LANL (2015); 1095 qubit
 - Continuing long history of quantum information/encryption R&D at Los Alamos
 - Neuromorphic, Probabilistic, and Custom computing

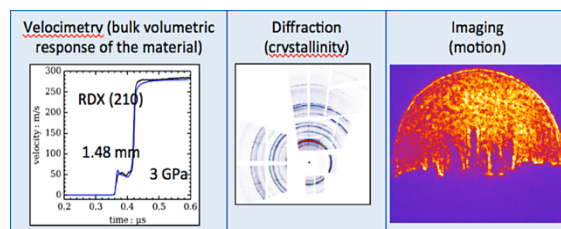


Next-generation computing will enable scientific discovery and solutions to the Lab’s most difficult mission challenges

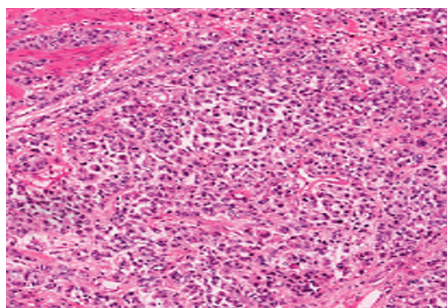
Data science (Machine Learning, Visualization) is evolving a critical part of today's scientific methodology at Los Alamos, e.g.,



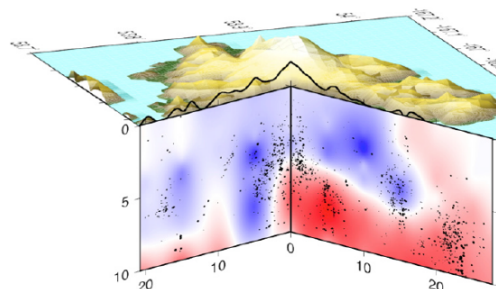
**Machine Learning
Accelerating Discovery
of New Materials**



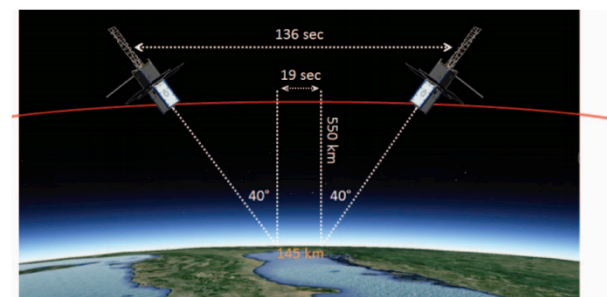
**Real-time Adaptive
Acceleration of
Dynamic Materials
Data Analysis**



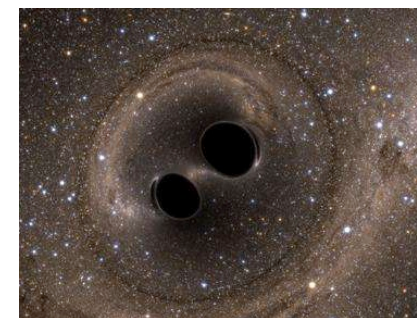
**Bioinformatics/
Emergent Diseases**



**Critical Stress
in Subsurface
Energy Dynamics
and Earthquakes**

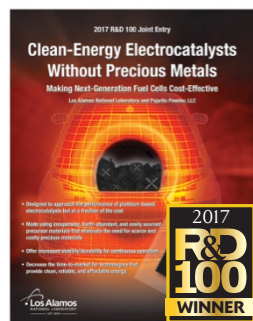


**Constellation of CubeSats
Carrying Ultra-Compact
Spectral Sensors**

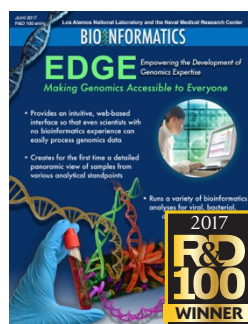


**Gravitational Wave
Emissions from
Colliding Black Holes
(LIGO)**

Eight (!) R&D 100 awards in 2017 reflect innovation and collaboration in support of our national security mission



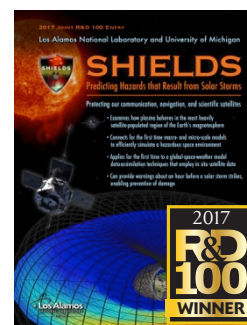
Making next generation fuel cells cost effective



Making genomics available to everyone



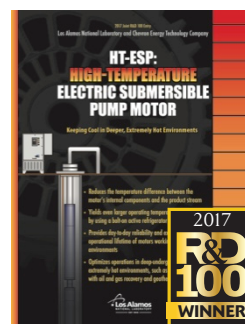
Informing decision making for geological carbon storage sites amidst uncertainty



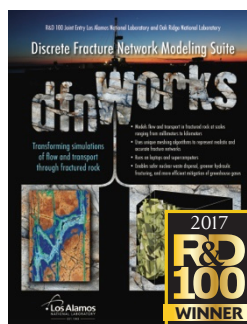
Predicting hazards that result from solar storms



Filling up hydrogen-fueled vehicles just became a lot safer



Keeping cool in deeper, extremely hot environments



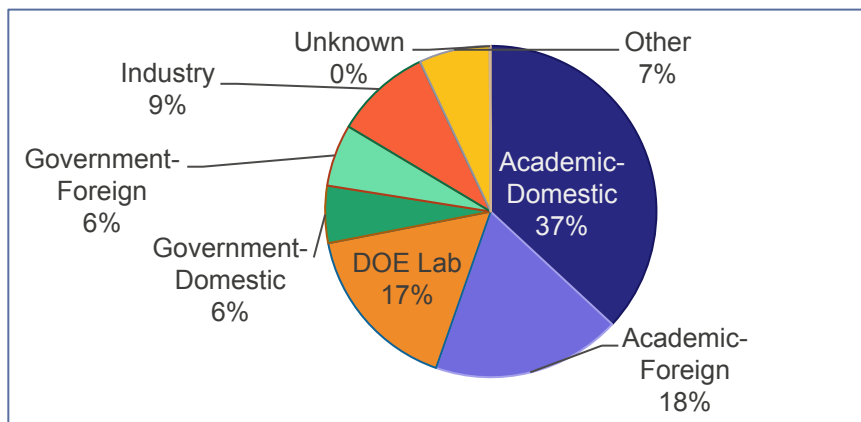
Transforming simulations of flow and transport through fractured rock



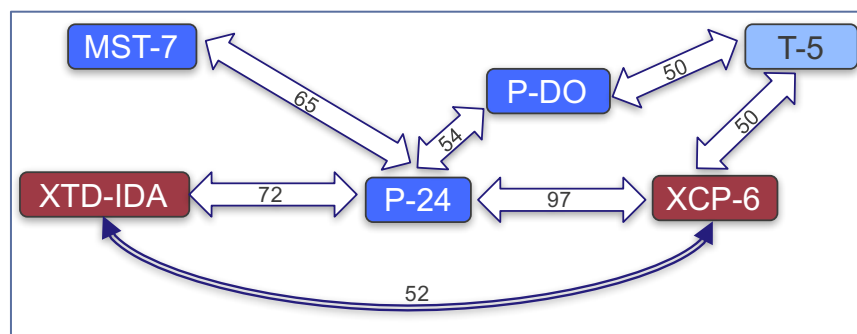
Using Wikipedia to perform real-time disease monitoring and forecasting

Collaborations measured by LAURs and LACPs

(LA Authors database)



The percentage distribution of collaborations by organization type for all categories of records in 2016



The number of records produced by intergroup collaboration for the highest collaborating groups in the 2016 data

Top External Collaborating Organizations for 2016

Institution	Collaborations
Lawrence Livermore National Laboratory	177
Sandia National Laboratory	129
Oak Ridge National Laboratory	126
University of New Mexico	83
Argonne National Laboratory	72
Lawrence Berkeley National Laboratory	59
Pacific Northwest National Laboratory	59
University of Texas	58
Kansas City National Security Campus	47
University of Michigan	45
National Security Technologies, LLC	42
Texas A&M University	40
New Mexico Institute of Mining & Tech.	38
Massachusetts Institute of Technology	36
Idaho National Laboratory	34
University of California, San Diego	34
University of Nevada	34
Atomic Weapons Establishment	32
North Carolina State University	31
University of California, Berkeley	30

The strength of our capabilities allows us to engage in multi-institutional partnerships



**Grid
Modernization
Laboratory
Consortium**



**Consortium for
Advanced Simulation
of Light Water
Reactors (CASL)**



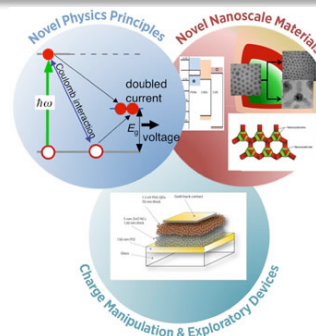
**Accelerated
Climate
Modeling for
Energy (ACME)**



**Next Generation
Ecosystem
Experiments
(NGEE)–Arctic**



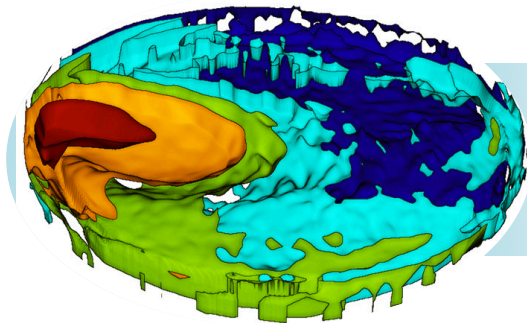
**Carbon Capture
Simulation
Initiative (CCSI)**



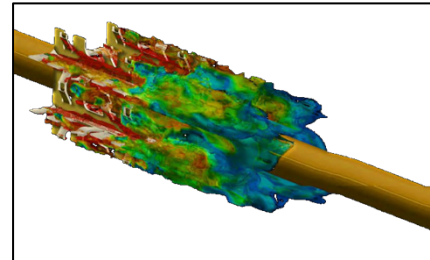
**Center for
Advanced Solar
Physics (CASP)**

And in turn, our participation in partnerships supports and enriches the Lab's multidisciplinary capabilities

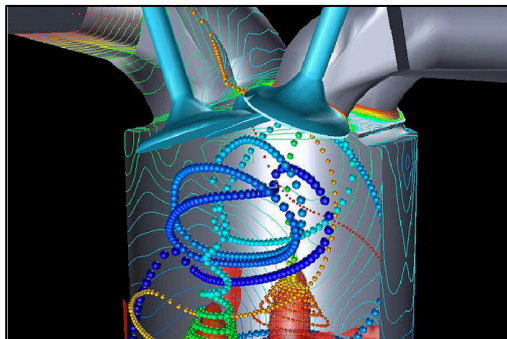
Partnering to deploy Los Alamos' Computational Fluid Dynamics capabilities



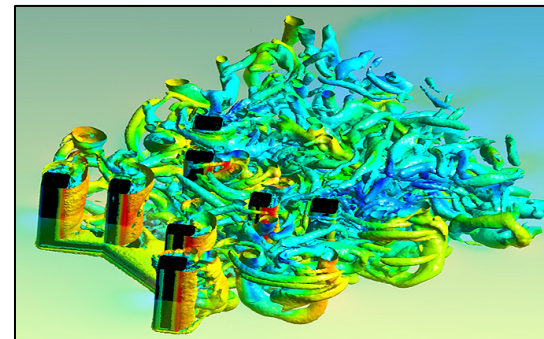
Ocean mixing simulations



Light-water reactor research



Improvements in engine efficiency



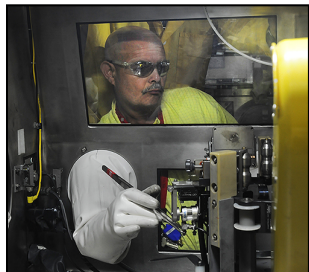
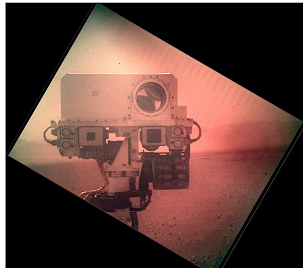
Ocean currents and offshore oil rigs

Los Alamos – DOE Labs – University – Industry Partnerships

Our partnerships are strategic and diverse

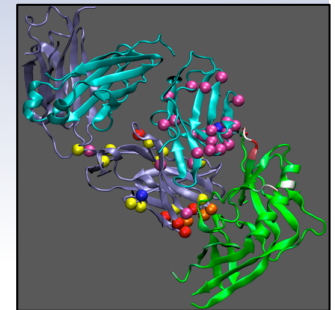
Science of sensors extends to multiple applications

Remote sensing and detection have multiple applications — from nonproliferation, space, defense, and intelligence to Mars Rover (**NASA, France**)



Global partners advance AIDS research

- Los Alamos developed the “mosaic vaccine” concept: a predictive framework to identify the most active epitopes in the immune system response and apply to a vaccine strategy
- We provide databases, theory, simulation, and high-performance computing to the **Global HIV Vaccine Enterprise** and the **CHAVI Consortium**



TALENT

Recruit, retain, and enhance critical skills for key, long-term mission objectives



1996: John Dunbar, PI
Scientist 4, LANL

5 postdocs and
1 grad student
contributed



Pulak Nath,
Scientist 4,
LANL

Expertise in microfabrication and
magnetics



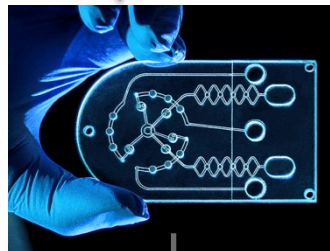
Alina Deshpande,
R&D Manager 4,
LANL
Expertise in flow
cytometry

CAPABILITY

Build the science and engineering capabilities for the Laboratory



- Multiplex assays for 6 pathogens
- Advanced microfluidic fabrication



"Liquid Logic"
Microfluidics Platform

- Modular
- Additive/subtractive manufacturing method
- Affordable mass production



Validation of
MOL-PCR with
multiplex assays

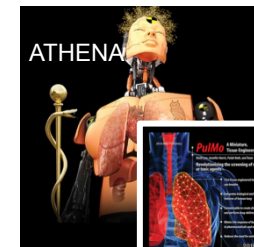


AGILITY

Apply capabilities for agile responses to national security challenges



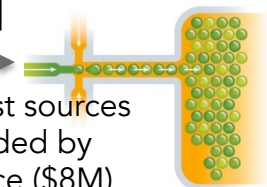
- Unable to integrate into an amplification device prototype



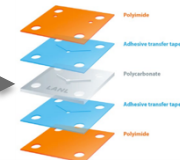
ATHENA
Miniature surrogate
human organs

Funded by DTRA
(\$19M), **2010** →

Finding the best sources
for biofuel; funded by
Office of Science (\$8M)



Measuring spent
fuel accurately,
quickly, cheaply



Reduce health risks; funded
by USDA (\$3M), **2012–2015**



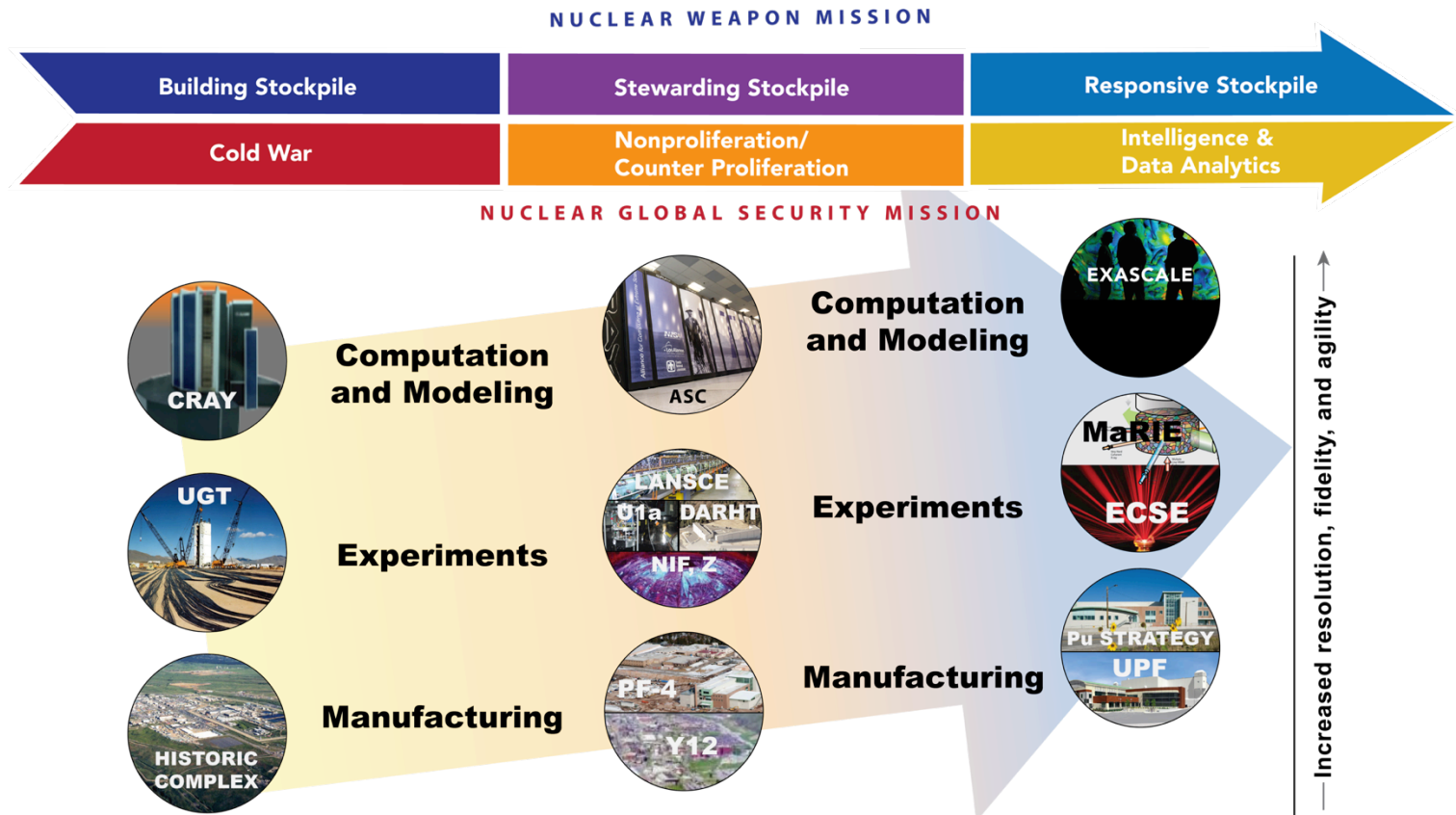
Evaluating
air sample
technology
for BioWatch
2010 →

**We take the long view
of investment impact**

UNCLASSIFIED

April 18, 2018 | 22

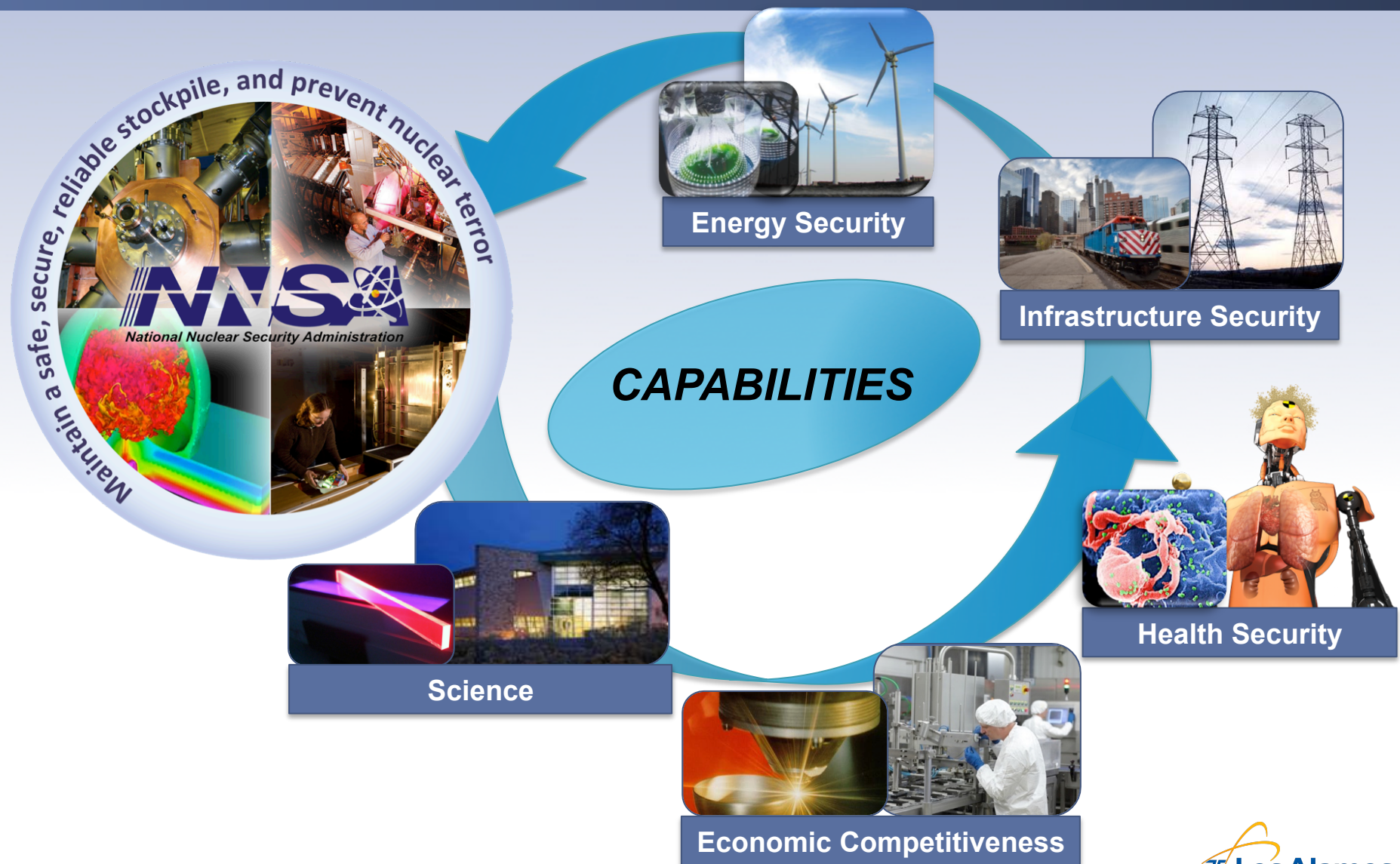
There is an enduring future for an integrated Laboratory — and the need for integrating assets at scale for national security



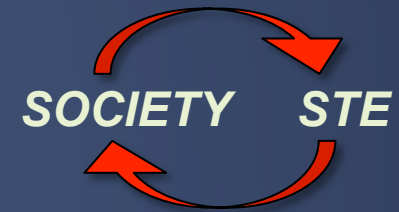
STRATEGIES:

- Accelerator
- Computing
- Energy Security
- Pu (...) Manufacturing/Production Science
- Lab-wide communication of Data Analytics techniques
- SPP/Tech Transfer

Our enduring STE strength for core missions provides the basis for contributing to emerging national security challenges, strengthening core LANL capabilities



We are privileged to be in the business of **Making History**



Wheel ...



Internet ...



Digital/Cyber/Vis/Ubiquitous Sensing... Robotics, AI, QC, CRISPR...



The technology cycle is accelerating rapidly and, hence, so are many new national security/societal imperatives:

In a data-democratic, technologically flatter world, the seamless and agile integration from discovery and innovation to impact will be a differentiator for national security and prosperity.

Los Alamos strives for success based on:

- Workforce Vitality & Inclusiveness
- Exciting STE & Mission
- Excellent scientific infrastructure
- Strategic Partnerships for THIS century's challenges, opportunities & STEM workforce
- Discussing and managing the ETHICS of dual-use STE

Status of Los Alamos' Scientific Environment

External Lab Environment

- **National Security domains driven by rapid new Technology growth & diversification**
 - NDAA's/NPR (→NNSA →LANL)
 - Science, Engineering, Technology balance
- **New Administration**
 - Priorities, Budgets: US jobs, Military, Regulatory Reform, Infrastructure...
- **DOE**
 - New Leadership & Org structure
 - New Priorities, Budgets:
 - Stockpile, Infrastructure, Security, Science–Innovation–Economy
 - Regularly reform
 - Lab Contracts, Governance
- **Declining/Fragmented Federal R&D era**
 - Science–Society compacts stressed
 - Tension in the “Science–Energy–Technology–Application” continuum
 - Competition–Collaboration balances
 - Minimal “ethics” debates
- **Exponential growth of new technology**
 - Dual-use balances & debates

Status of Los Alamos' Scientific Environment

Internal Lab Environment

- Focus/confidence **through** transitions (Directors, Contracts, Administrations, Missions...)
- Budgets growing and stable (for now?) with 2018 Congressional Bill & Omnibus & NPR
- **Balances:** Talent—Facilities—Infrastructure; Strategic Lab size, mission scope, R&D investment
- Staffing plans driven by major demographic trends and budgets: Mentoring/engaging/empowering the next generation/knowledge transfer
- STE Health & Performance metrics:
 - Quality, Impact, Relevance, Sustainability
 - “Health of Science” study (2017) and actions (Lab awareness, Collaborations, Infrastructure, Facilities)



Trump administration commentary on National Security Strategy

● Pres. Trump National Security Strategy Dec. 2017

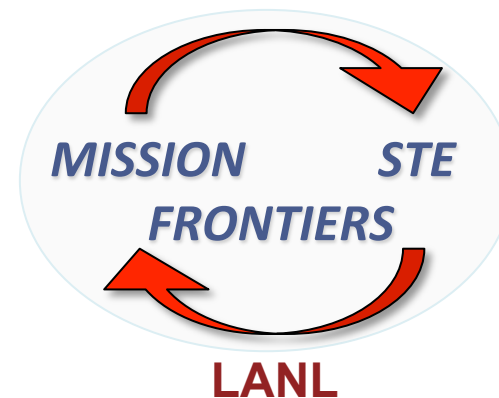
- ...Defend our National Security Innovation Base against competitors
- ...National laboratories, academia, private sector
- ...Discoveries into innovation and impact

● Sec. of Energy Perry PBR Commentary Feb. 2018

- ...Infrastructure to modernize the DOE nuclear enterprise
- ...Science dominance, spurring discovery & innovation at Labs to retain US preeminence in scientific research and technology commercialization

● Nuclear Posture Review Feb. 2018

- ...Hedging against an uncertain future security environment ...
- ...Workforce, Facilities, Infrastructure



What has changed / is changing for STE

- **Political/societal consensus on “National Security” post Cold War:
End of the peace-dividend optimism**

- ➔ Strategic Deterrence; Stockpile Responsiveness, Non/counter-proliferation; Cyber; Space; Bio; LYN ...

- **Data deluges** (experiment, computation, sensors, media)

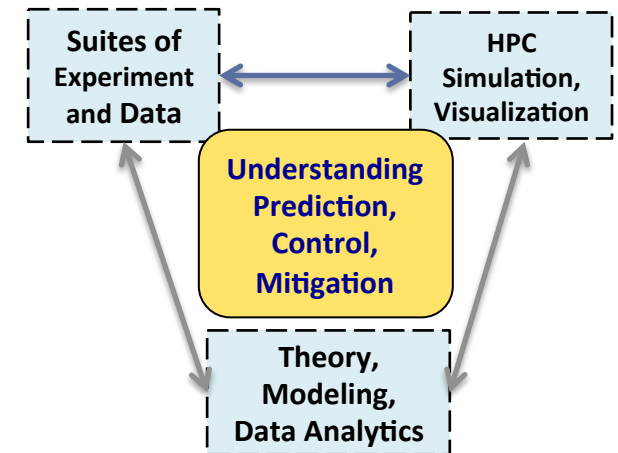
- Data analytics for prediction, UQ
 - Science-to-Innovation impact on programs, operations, economy: Educational and Public–Private environments

- **Ecosystem for national-scale societal challenges**

- Natural & Engineered Complex Systems/Networks
 - ➔ Space, CyberEnergy, Health, Infrastructure...
 - Collaboration and Competition strategies
 - Agile, interdisciplinary teaming

- **Lab growing in size, diversifying missions and capabilities: Valuing need for fully integrated LANL**

- Inclusive Workforce
 - Laboratory landlords



*The need for “Co-Design” using
THIS century’s tools for
the scientific method at scale*

Especially given demographics, requires sustained LANL focus on size AND balance:
Lab Awareness, Pipelines, Quality, Inclusiveness, Mentoring, Succession Planning

What should not change for Los Alamos STE

- **LANL as a LAB invests in evolving frontiers of**
 - National Security; R&D; Education
- **BALANCE: Delivering on Programs excellently, on time/cost TODAY *AND* preparing seed-corn for uncertain FUTURE missions**
 - We need to be ready with STE excellence, depth and breadth, confident in multidisciplinary teaming, and enabling successful careers
- **Valuing Talent, Mission, Capability, Agility**
- **Respecting and managing creative (“us vs. them”) tensions in growing, diversifying Lab:**
 - “PI–Team”
 - “Mission–Support”
 - “Line–Program”
 - “Basic–Applied”
 - “Long–Short Term”

Avoiding silos and technical insularity



Balanced investments for an integrated LABORATORY

Developing, Using, Evolving STE “Capabilities”